United States
Environmental Protection
Agency

Research and Development (481)
Solid Waste and
Emergency Response (5102G)

EPA542-F-97-012b
November 1997

EPA

Bioremediation of Chlorinated Solvents Consortium

RTDF

Remediation Technologies Development Forum

RTDF Action Teams

- Lasagna™ Partnership
- Permeable Reactive Barriers Action Team
- IINERT Soil-Metals Action Team
- Sediments Remediation Action Team
- *In Situ* Flushing Action Team
- Phytoremediation of Organics Action Team

What Is the Bioremediation Consortium?

The Bioremediation of Chlorinated Solvents Consortium is one of seven Action Teams of the Remediation Technologies Development Forum (RTDF). The RTDF was created in 1992 by the U.S. Environmental Protection Agency (EPA) to foster collaboration between the public and private sectors in developing innovative solutions to mutual hazardous waste problems. The Bioremediation Consortium was established in May 1993, when representatives from various companies, universities, the EPA, the Department of Defense (DOD), and the Department of Energy (DOE) met to discuss their shared interest in developing *in situ* bioremediation technologies to degrade chlorinated solvents in soils and ground water. As a result of that first meeting, the industrial partners of the Bioremediation Consortium—DuPont, Dow, General Electric, Monsanto, Zeneca, and Ciba-Geigy—signed a research agreement in September 1994. Agreements then were negotiated with EPA, the Air Force, and DOE to facilitate collaboration between the public and private sectors on the planned research projects. Two additional companies, Beak International and ICI Americas, joined the Bioremediation Consortium in Spring 1996.

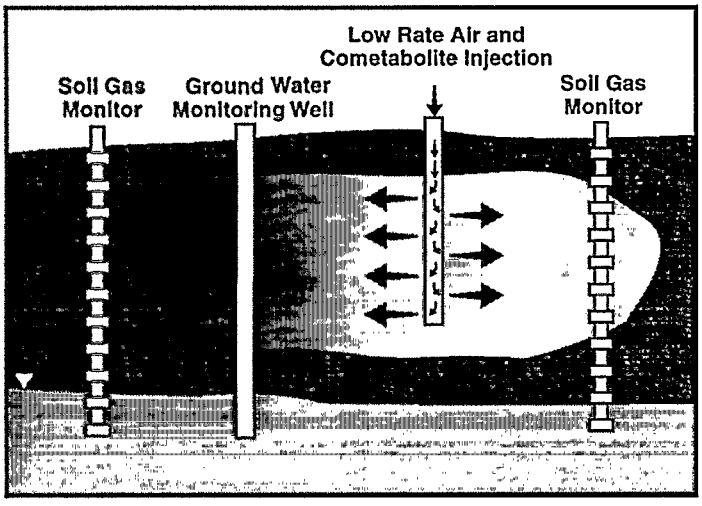
What Is the Problem of Concern?

Chlorinated solvents are the most common contaminants resulting from industrial and government operations. Used as solvents and degreasers, they are typically found in the soils and ground water adjacent to manufacturing, maintenance, and service installations around the world. Although complete degradation of chlorinated solvents to harmless end products is known to occur, a better understanding of how to predict and manage these degradation processes is needed to ensure their use as cost-effective, practical solutions.

What Is the Mission of the Bioremediation Consortium?

The mission of the RTDF Bioremediation Consortium is to accelerate the development of the most cost-effective *in situ* bioremediation processes for degrading chlorinated solvents. To accomplish this mission, the Consortium members jointly participate in the research, development, demonstration, and evaluation efforts necessary ***to achieve public and regulatory acceptance of these biological processes***. In addition, the data generated and experience gained by the Consortium in conducting field studies with these processes will be used to develop guidelines for their use at other contaminated sites.

Cometabolic Bioventing



What Processes Will Be Studied?

The Consortium focuses on three *in situ* bioremediation processes: cometabolic bioventing (for treatment in the vadose zone), intrinsic bioremediation (for treatment of the bulk of a plume), and accelerated anaerobic biodegradation (for treatment of more concentrated areas of a plume). These technologies are environmentally friendly; they cause minimal disturbance to the site as they require few surface structures. They also involve less cost than conventional pumping and treating. The Bioremediation Consortium initiated Phase I field tests of the three processes at Dover Air Force Base (AFB) in Dover, Delaware, in early 1995. Planning is underway to conduct Phase II field studies for each of the processes at another site.

Cometabolic Bioventing. Laboratory studies have shown that aerobic degradation of trichloroethene (TCE) in soils occurs most easily in the presence of a cometabolite, such as toluene, propane, or methane. Cometabolic bioventing uses a technique, similar to methods currently used in bioventing technology, to efficiently deliver oxygen and a cometabolite to the vadose zone in order to remediate TCE. This technology appears to have great promise. The objective of the RTDF cometabolic bioventing study is to develop a cost-effective process that promotes the cometabolic bioremediation of TCE and other chlorinated solvents. The Consortium initiated the Phase I Cometabolic Bioventing Study at Dover AFB, where TCE is present in sandy soil.

Intrinsic Bioremediation. Intrinsic bioremediation, or natural attenuation, of chlorinated solvents in ground water can occur at sites where indigenous microbial populations are present that can degrade these chemicals. Certain microorganisms are capable of detoxifying chlorinated methanes, ethanes, and aromatica by reductive dehalogenation or by oxidation. These processes can result in complete biodegradation to innocuous end products. The objective of the natural attenuation research effort is to quantitatively determine where, at what rate, and under what conditions natural attenuation occurs. Data from both field and laboratory studies will be used to develop a predictive natural attenuation model that will relate the measured degradation rates to the expected time course and outcome of intrinsic bioremediation. The Consortium initiated the Phase I Intrinsic Bioremediation Study at Dover AFB, where chloroethenes are present in shallow ground water. Key to selection of Dover AFB as the test site was the presence of an active microbial population, which was evidenced by the detection of degradation products at the site.

Accelerated Anaerobic Biodegradation. The rate of *in situ* anaerobic dechlorination is typically limited by the availability of food and nutrients for microbial growth. The purpose of the accelerated anaerobic degradation study is to discover what these nutritional limitations are and how to effectively deliver nutritional additions to the aquifer in order to facilitate the use of this technology at other sites. Other study objectives include determining which electron donors and acceptors best support anaerobic bioremediation; optimizing the chlorocarbon destruction rate; determining what factors control the degradation kinetics; and gathering cost and performance data. The Bioremediation Consortium has begun a Phase I field study to test the accelerated anaerobic process at Dover AFB.

What Are the Consortium Members' Roles?

Every Consortium member plays a specific role in the collaborative efforts for the three bioremediation processes. Each organization brings particular knowledge and expertise, as well as laboratory research, field studies, and resources necessary to conduct the projects and evaluate the effectiveness of the technologies.

The companies are sharing proprietary information, patented technologies, and their collective understanding and experience in bioremediation mechanisms and kinetics, hydrogeology, and nutrient delivery systems to support the development and testing of the three bioremediation processes.

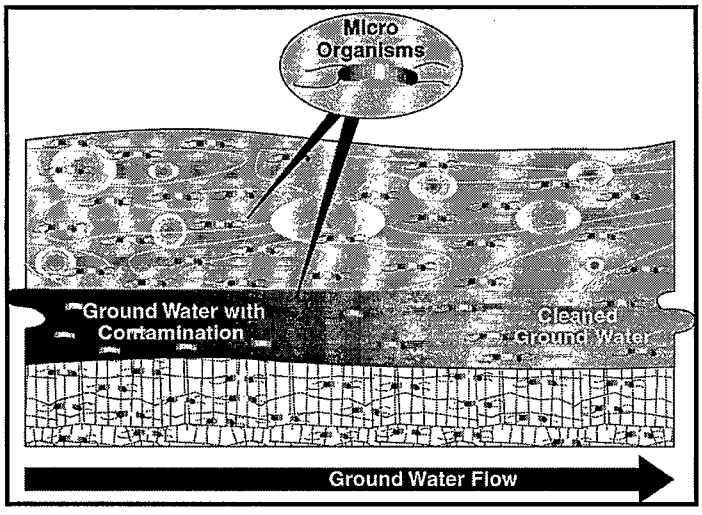
EPA's National Risk Management Research Laboratory (NRMRL) in Cincinnati, Ohio, is applying its knowledge and experience in developing bioventing processes to support the laboratory and field testing efforts for the cometabolic bioventing study. The Air Force brings its expertise in bioremediation and bioventing, as well as support for site characterization and field work at Dover AFB. DOE is applying its

substantial bioremediation expertise and laboratory experience, as well as tools for microbial characterization that will be useful in these studies.

What Activities Have Been Completed?

Cometabolic Bioventing. Using Dover AFB soil, intensive testing with microcosms revealed that cosubstrates propane and toluene stimulated TCE biodegradation at relatively fast rates. Soil column tests, established to simulate *in situ* air injection, confirmed the microcosm tests. Propane was chosen to be used as the cosubstrate for the field pilot test. The column tests also showed that propane stimulated

Intrinsic Bioremediation and Accelerated Anaerobic Biodegradation



cometabolic biodegradation of a co-contaminant at Dover AFB, trichloroethane (TCA). A pilot-scale field system was designed and installed at the Bldg. 719 site at Dover AFB, a jet engine maintenance facility with associated TCE- and TCA-contaminated soil. The pilot system is scheduled to begin operation in October 1997. A mathematical model is being developed to simulate cometabolic bioventing. It will be tested against the monitoring data generated in the field test.

Accelerated Anaerobic Biodegradation. As part of pilot start-up procedures, a tracer test was performed to monitor hydrologic performance within the test cell. Data from this test were used to calibrate the flow and transport model developed during the pilot design. Based on tracer test and operating data from the first year of operation, the pilot is performing as designed in terms of nutrient delivery and water movement. PCE and TCE have been degraded to levels below detection limits in approximately half of the pilot cell. Significant degradation of these compounds has occurred over the rest of the pilot area. Cis-DCE levels have increased with no apparent degradation of this daughter product to date. As a result of this development, the Consortium elected to augment a portion of the pilot with microorganisms that have the ability to further degrade DCE and vinyl chloride. The Consortium is hopeful that the augmenting organisms will complete the degradation process after sufficient residence time has elapsed. Operation and evaluation of the pilot is scheduled to continue until February 1998.

Intrinsic Bioremediation. A modular computer model for simulating natural attenuation in ground water has been developed. The Consortium intends to use data collected as part of the intrinsic pilot in the application of the model to the Dover AFB site. The model will be in the public domain and can be used on personal computers. A detailed analysis of ground-water data from site-monitoring wells was used to calculate the apparent flux of chlorinated compounds across the plume. Results are being compared with similar calculations made using ground-water data collected as part of an elaborate "transect" study involving over 100 discrete ground-water samples. The samples were collected along three "transects" of the plume using direct-push sampling techniques. In addition to sample collection, individual measurements of hydraulic conductivity were made at each location. The Consortium will evaluate these two methods of flux calculation within the next program year. The intrinsic bioremediation study is scheduled to run through 1998 at Dover AFB.

What Activities Are Planned?

Research efforts on the three Phase I projects will continue until 1998. Hill AFB has been chosen for Phase II Cometabolic Bioventing work. Currently, lab work using site soil is underway. The Consortium continues to search for sites for Phase II Intrinsic Bioremediation and Accelerated Anaerobic Biodegradation work.

What Are the Funding Sources?

EPA provides the necessary funds and staff to support and facilitate Bioremediation Consortium meetings. Staffing, funding, and equipment needed to develop and test these three bioremediation processes are being provided by the Bioremediation Consortium members. Both EPA and the Air Force work through a Cooperative Research and Development Agreement, which allows government agencies to work with industry on collaborative research efforts. DOE has contributed significant funding for the intrinsic bioremediation and accelerated anaerobic biodegradation Phase I projects. The Phase I cometabolic bioventing field study has been primarily funded by the EPA, the Air Force, and Zeneca.

Who Are the Consortium Members?

Beak International
Ciba-Geigy Corporation
Dow Chemical Company
DuPont
General Electric
ICI Americas
Novartis
Zeneca, Inc.

U.S. Air Force
U.S. Department of Energy
U.S. Environmental Protection Agency

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Remediation Technologies Development Forum

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